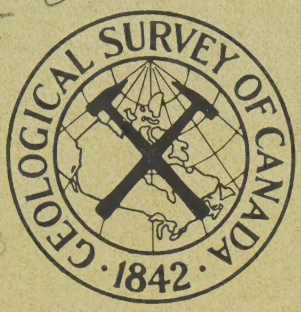

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

PAPER 61-13

CAMSELL BEND AND ROOT RIVER MAP-AREAS, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

(Report, 2 maps, 2 figures)

R. J. W. Douglas and D. K. Norris

1961
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R. J. W. Douglas and D. K. Norris

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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CAMSELL BEND AND ROOT RIVER MAP-AREAS, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

INTRODUCTION

These areas are situated in southwestern District of Mackenzie. Camsell Bend map-area is bounded by latitudes 62 and 63°N and longitudes 122 and 124°W; Root River map-area lies to the west, between longitudes 124 and 126°W. The map-areas form part of the region investigated geologically in 1957 on Operation Mackenzie, a general account of which has been published (Douglas, 1959a).[1]

Officers of the Geological Survey of Canada on Operation Mackenzie were W. B. Brady, B. G. Craig, R. J. W. Douglas, P. Harker, D. J. McLaren, A. W. Norris, D. K. Norris, B. R. Pelletier, and D. F. Stott. They were assisted in the field by D. A. Andrews, F. J. A. Arthur, R. K. Broeder, K. P. R. Cole, W. N. Hamilton, I. M. Harris, R. N. McCowan, D. B. McKennitt and J. B. Read. Crew of the helicopters, supplied by Associated Helicopters Ltd., were N. R. Staniland, R. Huff, J. Brochu, and R. Barnes; and crew of the Beaver aircraft, supplied by Pacific Western Airlines Ltd., were W. McKinney and J. Furber. A boat and barge were operated by G. P. J. Turner and D. Turner. Other members of the party included W. T. Spratt, radio operator, and E. A. Konisenta, H. Martell and M. McKay, canoemen. To all these men, the writers and other officers of the party extend their appreciation.

The geology of both map-areas was mapped and compiled jointly by the authors. Sections of the lower part of the Palaeozoic succession were examined by A. W. Norris, W. B. Brady and B. R. Pelletier; those from the higher part were examined by D. J. McLaren and P. Harker. Fossils have been examined and identified from the Devonian by D. J. McLaren and A. W. Norris and from older beds by B. S. Norford, G. W. Sinclair and R. Thorsteinsson. Faunas of late Upper Devonian age have been identified by P. Sartenaer, a post-doctorate fellow with the Geological Survey. Subsurface data is summarized from lithologic logs prepared by H. R. Belyea and D. C. Pugh.

References

Bostock, H. S.
1948: Physiography of the Canadian Cordillera, with Special Reference to the Area North of the Fifty-fifth Parallel; Geol. Surv., Canada, Mem. 247.

[1] Names and dates in parentheses refer to publications listed in the References.

Cameron, A. E.
1918: Explorations in the Vicinity of Great Slave Lake; Geol. Surv., Canada, Sum. Rept. 1917, pt. C, pp. 21-27.

Dann, G.
1952: Northwest Territories Field Trip 1952; Dept. Northern Affairs, Nat. Resources, report to Minister by Hudson's Bay Oil and Gas Co., Ltd; Calgary, Alta., Oct. 1952, open file Calgary and Ottawa.

Douglas, R.J.W.
1959a: Light Helicopter Reconnaissance in Interior Plains and Mountains, In Helicopter Operations of the Geological Survey of Canada; Geol. Surv., Canada, Bull. 54.

1959b: Great Slave and Trout River Map-areas, Northwest Territories; Geol. Surv., Canada, Paper 58-11.

Douglas, R.J.W., and Norris, A.W.
1960: Horn River Map-area, Northwest Territories; Geol. Surv., Canada, Paper 59-11.

Douglas, R.J.W., and Norris, D.K.
1959: Fort Liard and La Biche Map-areas, Northwest Territories and Yukon; Geol. Surv., Canada, Paper 59-6.

1960: Virginia Falls and Sibbeston Lake Map-areas, Northwest Territories; Geol. Surv., Canada, Paper 60-19.

Hage, C.O.
1945: Geological Reconnaissance Along Lower Liard River, Northwest Territories, Yukon and British Columbia; Geol. Surv., Canada, Paper 45-22.

Hunt, C.W.
1954: Normal Devonian Sequence in Southern Mackenzie Basin, Western Canada; Bull. Am. Assoc. Petrol. Geol., vol. 38, pp. 2290-2301.

Hume, G.S.
1922: North Nahanni and Root River Area, and Caribou Island, Mackenzie River District; Geol. Surv., Canada, Sum. Rept. 1921, pt. B, pp. 67-78.

1954: The Lower Mackenzie River Area, Northwest Territories and Yukon; Geol. Surv., Canada, Mem. 273.

Kindle, E.M., and Bosworth, T.O.
1921: Oil-bearing Rocks of Lower Mackenzie River Valley; Geol. Surv., Canada, Sum. Rept. 1920, pt. B, pp. 37-63.

Kingston, D.R.
1951: Stratigraphic Reconnaissance Along Upper South Nahanni River, Northwest Territories, Canada; Bull. Am. Assoc. Petrol. Geol., vol. 35, No. 11, pp. 2409-2426.

Whittaker, E.J.
1922: Mackenzie River District Between Great Slave Lake and Simpson; Geol. Surv., Canada, Sum. Rept. 1921, pt. B, pp. 45-55.

Williams, M.Y.
1922: Exploration East of Mackenzie River Between Simpson and Wrigley; Geol. Surv., Canada, Sum. Rept. 1921, pt. B, pp. 56-66.

1923: Reconnaissance Across Northeastern British Columbia and the Geology of the Northern Extension of Franklin Mountains, Northwest Territories; Geol. Surv., Canada, Sum. Rept. 1922, pt. B, pp. 65-87.

PHYSICAL FEATURES

Camsell Bend and Root River map-areas include part of the western Interior Plains, some elements of Franklin Mountains, and parts of Mackenzie Plain and Mackenzie Mountains.

The western part of the Interior Plains within Camsell Bend map-area is limited on the west by McConnell and Nahanni Ranges. Mackenzie River—the main artery for boat and barge in this part of the Northwest Territories—flows west-northwest across the Plains and changes abruptly to a northerly course at Camsell Bend in Mackenzie Plain. Willowlake River is the second major river; it flows westerly through nearly flat shale and thick Pleistocene deposits.

Many large lakes permit easy caching of gasoline by fixed-wing aircraft throughout the summer season. Some however are strewn with boulders—a serious hazard to float-equipped aircraft at low water late in the season.

Elevations on the Plains range from less than 500 feet along Mackenzie River to more than 2,000 feet on Ebbutt Hills. The Plains are heavily wooded and mantled by glacial debris, so that the few bedrock exposures are limited to the shores of Mackenzie and Willowlake Rivers, to the escarpments formed by the more resistant beds, and to Willow Ridge—a narrow anticlinal inlier of resistant Middle Devonian and older rocks.

McConnell Range occurs as two physiographic elements of Franklin Mountains in Camsell Bend map-area. Both are of limited extent and consist of resistant carbonates that give rise to stripped surfaces along the west flank of these elements.

Camsell Range rises from Mackenzie Plain near the mouth of North Nahanni River and extends well beyond the north boundary of the map-area. It is a narrow, linear to gently sinuous feature with a steep east-facing scarp for most of its length. Most of the range lies above tree-line and several peaks exceed 3,500 feet. The flood plain of North Nahanni River separates Camsell Range from the northern continuation of Nahanni Range of adjacent Sibbeston Lake map-area.

West of southern Camsell Range is northern Ram Plateau—a dissected dome-shaped element flanked on the east by North Nahanni River.

Mackenzie Plain extends as far west as the eastern scarp of Iverson Range, and except where it is interrupted by the various elements of Franklin Mountains mentioned above, it is underlain by relatively soft shales, sandstones and carbonates of Upper Devonian formations. However, one dome-shaped structure is outlined by stripped surfaces on the Middle Devonian Nahanni formation in south-eastern Root River map-area. Within the map-areas the North Nahanni, English Chief, and Root are the principal rivers draining Mackenzie Mountains and crossing the Plain.

North Nahanni River appears to have once flowed through Carlson Lake and along the course of Carlson Creek into Root River on the west flank of Camsell Range. This presumably occurred when the continental ice-sheet occupied the western part of the Interior Plains and invaded the lower reaches of North Nahanni and Root Rivers. Mackenzie Plain ranges in elevation from less than 500 feet on Mackenzie River at Camsell Bend to more than 3,000 feet on the stripped surfaces in resistant Upper Devonian formations north of Carlson Lake. It is largely covered with trees and scrub.

Mackenzie Mountains in Root River map-area include parts of the Canyon and Backbone Ranges (Bostock, 1948). The Canyon Ranges have a distinct north-south grain and are characterized by sub-linear mountain ranges in which canyons have been cut by most of the major streams. Between these ranges and domes, linear valleys lie at elevations of about 1,500 feet, contrasting to the 4,000- to 5,000-foot elevations of the ranges. The Canyon Ranges include Iverson, Whittaker, Delorme, and Manetoe Ranges and the northern termination of Nahanni Plateau.

The Backbone Ranges are characterized by a few broad valleys interspersed in strongly dissected plateaux with a relief of 2,000 to 3,000 feet; some of the higher peaks, such as those in Thundercloud Range, are close to 7,500 feet high. The north-south grain of the country is not nearly as strong in the Backbone Ranges as it is in the Canyon Ranges of Root River map-area. The Backbone Ranges in this map-area include Painted Mountains, characteristically formed of nearly flat, varicoloured strata; Sombre Mountains, composed of generally flat lying, dark grey rocks; and Thundercloud Range, with both brightly coloured and dull rocks, mostly gently dipping. The principal valleys are either longitudinal or transverse to the ranges. The former are commonly carved in recessive shales of Upper Devonian age and lie about 3,000 feet in elevation. The transverse valleys, both broad and narrow, cut indiscriminately across the ranges.

Few lakes in Mackenzie Mountains are accessible by float-equipped fixed-wing aircraft. Heavily laden aircraft can take off and land from Trench Lake, immediately west of Iverson Range and south of English Chief River; from a small unnamed lake on the west flank of Painted Mountains; and from Bell Heather Lake on the north flank of Sombre Mountains near the west boundary of Root River map-area. Bell Heather Lake is strategically important because of its location in the heart of Mackenzie Mountains and because its size permits the use of large aircraft for hauling men and equipment.

STRATIGRAPHY

Camsell Bend and Root River map-areas extend from the western Interior Plains on the east to deep within Mackenzie Mountains on the west. The nature and thickness of the stratigraphic succession varies considerably, depending on position relative to the plains or the mountains. In general, about 2,000 to 3,000 feet of strata underlies the plains east of the map-areas. Along the mountain front in McConnell Range of Franklin Mountains, some 6,000 feet is present between the top of the Middle Devonian and the Proterozoic. In Whittaker and Delorme Ranges of Mackenzie Mountains, however, some 15,000 feet of strata was measured below the top of the Middle Devonian; in spite of this great thickness it is unlikely that the top of the Proterozoic was reached.

The succession in Franklin Mountains in McConnell Range and in the vicinity of Root and North Nahanni Rivers has been known for some time through the work of Williams (1922, 1923) and Hume (1922). Several of their rock units were named, and insofar as possible at this time, they are recognized in this report. The thick succession in Mackenzie Mountains and Liard Plateau has been described in previous reports (Douglas and Norris, D.K., 1959, 1960) and additional data is presented here. The succession has been divided into a large number

of map-units, some of formational status. Other map-units have been introduced to avoid implying correlation of strata in the different ranges where uncertainties exist, and still others to embrace sequences of rocks that were undivided or indivisible.

In this report, names are proposed for some map-units that are considered to have formational status. These units comprise rocks of Ordovician, Silurian and Devonian age exposed in Mackenzie Mountains. The new formations—the Whittaker, Delorme, Camsell, Sombre, Arnica, Manetoe, Funeral, Landry and Headless—are established primarily on the basis of gross lithology and general mappability in these and adjacent map-areas to the south and north; their designation does not fully take into consideration the results of stratigraphic and palaeontological studies still in progress.

PALAEOZOIC

Ordovician and Older (?)

Sunblood Formation (1)

The oldest beds exposed in the map-areas comprise a distinctive reddish weathering unit that occurs in the axial regions of the major anticlinal structures. These beds are referred to the Sunblood formation on the basis of general lithological similarity, stratigraphic position and the presence of Middle Ordovician fossils. The Sunblood formation—proposed by Kingston (1951)—is used here as modified by the writers (Douglas and Norris, 1960) in Virginia Falls map-area. In general it is more arenaceous and, as fossils were not found throughout the formation, the unit as mapped may include some older beds.

The formation was examined in the cores of Whittaker and Delorme Ranges. At the former locality a total of 1,615 feet of beds was measured. A conspicuous orange-weathering limestone marks the top of the unit. The upper 260 feet consists of grey-weathering, fine-grained, dark grey limestones and calcareous shales containing Middle Ordovician fossils. Malachite, azurite and goethite occur 70 feet above the base of the unit. The underlying part, 680 feet thick, is composed of interbedded reddish-orange- to brown-weathering, brownish grey, fine- to medium-grained, medium- to thin-bedded, sandy or silty limestones; fine-grained dolomites; and calcareous to dolomitic sandstones. Copper minerals occur 650 feet above the base. These beds and those lower in the section were found to be unfossiliferous. Underlying strata comprise 335 feet of fine-grained grey limestone that is thin- to medium- and thick-bedded and forms a low cliff. These are underlain by the lowest beds exposed which consist of 340 feet of arenaceous dolomites—light grey, fine- to medium-grained and brown-weathering; interbedded with sandstones—dark grey, medium-grained and grey-weathering.

On Delorme Range at the headwaters of Pastel Creek, 1,600 feet of beds ascribed to the Sunblood formation were measured. These consist of silty and sandy dolomites—medium-grey, fine- to cryptograined and weathering rusty-orange to light brown; interbedded with some sandstone that is fine-grained, dolomitic, pale brown and thinly bedded. Poorly preserved fossils were found to within about 100 feet of the base of the section. The section described is bounded on both sides by faults and faces westward; accordingly, the stratigraphic relationship to the overlying rock unit is not apparent.

Ordovician and Younger
(Map-units 2 to 10)

Map-unit 2

This map-unit occurs only in southwestern Root River map-area. It was not examined. The area shown underlain by map-unit 2 is a structural continuation of 'map-unit 3' of Virginia Falls map-area (Douglas and Norris, D.K., 1960) comprising about 2,500 feet of dark grey, massive to medium-bedded, fine- to cryptograined, grey-weathering limestone with minor interbedded dark grey shale, siltstone and sandstone. Several massive beds of light grey, medium- to coarse-grained dolomite occur near the middle.

Whittaker Formation (3)

Overlying the Sunblood formation except where map-unit 2 is present, is a thick sequence of limestones, dolomites and shales—called the Whittaker formation. Sections were measured on Pastel Creek in Delorme Range and on the east flank of Whittaker Range, the type section. The Whittaker formation is characteristically grey weathering, and in better exposed regions it consists of alternating units of light- and dark-grey-weathering beds. In general, throughout much of the area the formation is divisible into three parts: the lower and middle parts are more massive and mainly carbonate; the upper part is more recessive and mainly shaly limestone and siltstone. The lower and middle parts are approximately equivalent to map-unit 2.

On Whittaker Range the formation is 4,070 feet thick. The lower part, 1,320 feet thick, consists of limestone—dark grey to grey, fine- to medium-grained, thinly bedded and grey-weathering. The brachiopod fauna indicates a Late Ordovician age according to Norford. The middle part is 860 feet of mainly fine-grained, dark grey dolomites—medium- to thick-bedded, dark-grey- to light-grey-weathering, and sparsely cherty, and, in the more massive beds, commonly fossiliferous. The fossils are colonial and simple corals, and according to Norford and Sinclair they are Late Ordovician in age. The upper part, about 1,890 feet thick, consists of argillaceous

TABLE OF FORMATIONS*

Era	Period or Epoch	Group or Formation (map-unit)	Lithology	Thickness (feet)
Ceno-zoic	Pleistocene and Recent	28	Alluvial sands, silts and muds of Mackenzie and lower North Nahanni Rivers	
Meso-zoic	Cretaceous	27	Shale, dark grey, concretionary, gypsiferous	
Palaeozoic	Mississippian (?)	26	Shale, grey, compact	100+
	Upper Devonian	25	Shale, siltstone and limestone (equivalent to map-unit 23 and younger)	
		24	Siltstone, calcareous, and silty shale, green to reddish brown; limestone, argillaceous	575
		23	Shale, grey and greenish grey; limestone, siltstone	700
		22	Limestone, siltstone, shale and sandstone (equivalent to map-units 19 - 21)	
		21	Sandstone, calcareous; siltstone; shale and mudstone, olive-grey	660
		20	Limestone, massive-bedded, reefy	150±
		19	Sandstone, calcareous; siltstone; shale, olive-grey, silty	650
		Fort Simpson (18)	Shale and mudstone, grey; limestone; siltstone (may include Horn River formation)	2,500-3,800
		Horn River	Shale, black, silty, pyritic; brown streak (in subsurface only)	110
		Nahanni (17)	Limestone, fine- to medium-grained, grey, fossil fragmental, massive to thick-bedded	300-965

Palaeozoic	Middle Devonian	Headless (16)	Limestone, argillaceous, thinly bedded; shale, calcareous; recessive	130-200
		Landry (15)	Limestone, crypto- to medium-grained, grey; thick-bedded; grey-weathering	300-500
		Bear Rock (14)	Breccia: silty, argillaceous limestone; orange-weathering	1,100±
		Funeral (13)	Limestone, argillaceous, thinly bedded; shale, calcareous, grey; buff-weathering	1,300±
		Manetoe (12)	Dolomite, coarsely crystalline, grey; thick-bedded	150-500±
		Arnica (11)	Dolomite, crypto- to fine-grained, dark grey to black; banded grey-and-black-weathering	1,300-2,100
	Ordovician and younger	Sombre (10)	Dolomite, crypto- to fine-grained, light and medium grey; banded grey-and-light-grey-weathering	0-4,100
		(9)	Dolomite, fine-grained, light brown; silty dolomite; sandstone; buff-weathering	910±
		(8)	Dolomite, fine-grained, grey; massive-bedded	1,200±
		Mt. Kindle (7)	Dolomite, fine- to medium-grained, grey; massive-bedded	900±
		(6)	Dolomite, fine-grained, grey; dolomite, silty; limestone; banded buff-weathering	4,000-5,000
		Camsell (5)	Breccia: cryptograined, grey limestone; grey-, brown-, yellow-, orange-, and red-weathering	1,400-1,750
		Delorme (4)	Dolomite, fine-grained, grey; limestone, fine-grained, grey; siltstone; shale, grey; buff-weathering	3,250-3,800
		Whittaker (3)	Limestone, dark grey, argillaceous; dolomite, dark grey, massive; shale, calcareous, dark grey; grey-weathering	2,890-4,070
		(2)	Limestone, dark grey; dolomite, massive; shale; grey-weathering	2,530±
	Ordovician and older(?)	Sunblood (1)	Limestone, dark grey; dolomite, sandy; sandstone; grey-, orange-, and red-weathering	1,600+

*Relative position of map-units in this table does not necessarily imply relative stratigraphic position.

limestone—dark grey to greyish black, fine-grained and platy to thinly bedded—with alternating thin beds of black and dark grey siltstone in the basal part. The limestones contain a graptolitic fauna of Llandoverian-Wenlockian age according to Norford and Thorsteinsson.

On Pastel Creek the Whittaker formation is 2,890 feet thick; the lower part comprises 1,330 feet, the middle 580 feet, and the upper 980 feet. These units are essentially similar in lithology to those on Whittaker Range.

Delorme Formation (4)

The term Delorme formation is applied to the sequence of buff- and light-brown-weathering, thinly bedded limestones, dolomites, and shales that overlie the Whittaker formation and underlie the Camsell formation. The Delorme was measured at the headwaters of Pastel Creek on Delorme Range, and on the east flank of Whittaker Range; the former is designated the type locality. Throughout most of the area the formation is characteristically recessive, slope-forming, talus-covered, and weathers alternating buff to light and dark brown; locally, on the east side of Whittaker Range, it also weathers orange and reddish brown. Some parts, particularly the middle, are more resistant and form cliffs or ridges.

On Delorme Range the formation is 3,250 feet thick. The basal 500 feet consists mainly of interbedded soft dark grey shales and clayey black argillaceous limestones and dolomites. These basal beds carry fossils identified by Norford as being Silurian, probably Ludlovian in age. These beds are succeeded by 1,300 feet of fine-grained, light grey, granular dolomites—in part massive and resistant, varying to whitish grey and brown, medium- to coarse-grained, and sparsely porous and vuggy. The next 700 feet comprises fine-grained granular and silty dolomites—medium- and evenly bedded; these beds contain fossils of Silurian to Devonian age according to Norford and A. W. Norris. The uppermost 750 feet, mainly concealed, is composed partly of cryptograined limestone—dark grey and thinly and evenly bedded.

On the east flank of Whittaker Range the Delorme formation is 3,800 feet thick. The lower 2,000 feet comprises interbedded dark grey to black shale and thinly bedded dolomitic siltstones, weathering brilliant orange, with some more-massive, ridge-forming, medium-grey dolomites and limestones. These beds are succeeded by 1,200 feet of dark grey cryptograined limestone—variably silty and sandy and weathering orange. The top 600 feet consists of recessive, thinly bedded, fine-grained, light grey limestones.

Camsell Formation (5)

The resistant ridge-forming limestones and breccia that succeed the Delorme formation and are overlain by the Sombre formation are named the Camsell formation. The Camsell is 1,400 and 1,750 feet thick on Whittaker and Delorme Ranges respectively.

In northern Root River map-area it is characteristically formed of grey cryptograined limestone, weathering light- to medium-grey and either in massive beds or brecciated on a large scale. Joint faces, pockets and the breccia matrix consist of coarse calcite or limonite and ochre, that are brown, yellow, or brilliant orange and red in colour. Breccia fragments are up to 10 feet or more in diameter and may be very angular or subrounded. Salt casts are present on some bedding surfaces. No fossils were obtained.

In south-central Root River map-area the Camsell formation consists of alternating thick-bedded, fine-grained, medium-grey-weathering limestone and shaly, fine-grained, orange-weathering, recessive limestone; the colour-banding is its most striking characteristic. The formation thins southward, possibly as a result of pre-Sombre erosion. In the southwestern part of the area and in northern Manetoe Range, equivalent strata are included in map-unit 6.

Map-unit 6

This unit includes undifferentiated rocks of the Camsell and Delorme formations and, in southwestern Root River map-area where it is underlain by map-unit 2, it probably includes some of the upper part of the Whittaker formation.

In northern Manetoe Range and Nahanni Plateau the Camsell loses its typical characteristics, and is only separated from the underlying Delorme formation where the structure is simple or the formations are in structural continuity. In this region map-unit 6 corresponds to 'map-unit 6' of Virginia Falls map-area to the south (Douglas and Norris, D.K., 1960). The uppermost part is approximately the map equivalent of the Camsell formation and the remainder is the equivalent of the underlying Delorme formation (see Fig. 1).

In southwestern Root River map-area, unit 6 was only examined at one locality; there the upper part was seen to include interbedded fine-grained, dark grey, silty, finely laminated dolomite, and similar but light grey dolomite. These dolomites, alternating in units 5 to 10 feet thick, weather grey and yellowish grey imparting a distinctive banded appearance to the rocks. In general aspect, some parts are similar to the limestones and shales included in 'map-unit 5' of Virginia Falls map-area, with which this unit is contiguous; but other parts also have the appearance of the dolomites of 'map-unit 6' of that

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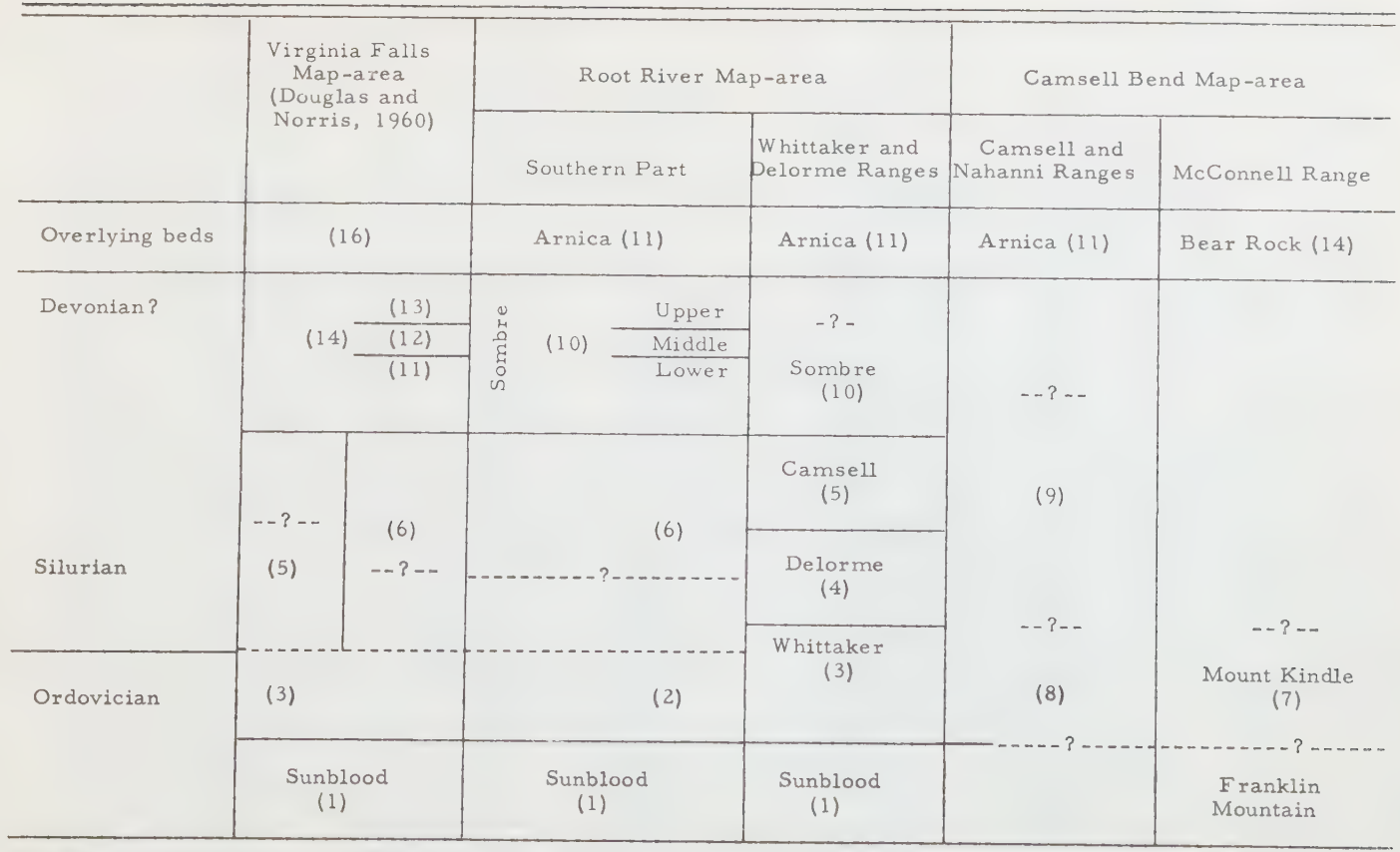

Figure 1. Correlation of Ordovician, Silurian and Devonian (?) formations and map-units of Camsell Bend, Root River and Virginia Falls map-areas.

area. The upper half is resistant and mountain-forming whereas the lower half is more recessive and is probably shaly.

Mount Kindle Formation (7)

The term Mount Kindle formation was proposed by Williams (1922) and further described the following year (Williams, 1923) for beds in McConnell Range in the vicinity of Mount Kindle and Mount Cap. The Mount Kindle formation forms the cores of the anticlinal folds in the southern part of McConnell Range in northern Camsell Bend map-area. The formation was not examined.

North of Camsell Bend map-area the Mount Kindle formation comprises about 900 feet of rather massive, medium-grey, fine- to medium-grained dolomite that weathers light grey and locally yellowish grey. The more massive beds contain large compound corals and other fossils dated by Norford as late Ordovician. Formations lower in the stratigraphic succession are not exposed within the southern part of McConnell Range.

Map-units 8 and 9

On northern Nahanni Range in southern Camsell Bend map-area, beds designated as map-units 8 and 9 are present above the Nahanni thrust.

Map-unit 8 is a continuation of 'map-unit 4' of Sibbeston Lake map-area (Douglas and Norris, D.K., 1960) which was described as massive, reefy, medium-grey, fine-grained dolomites, in part porous and vuggy. The contained fauna indicates a late Ordovician age according to Norford.

Map-unit 9, which overlies map-unit 8 on Nahanni Range, includes at the base, the beds designated as 'map-unit 10' in Sibbeston Lake map-area; the latter beds comprise 260 feet of dolomite interbedded with sandstone. Map-unit 9 of Camsell Bend map-area also includes some overlying dolomites that were provisionally included in 'map-unit 16' of Sibbeston Lake map-area. These dolomites were examined at Little Doctor Lake where they are about 650 feet thick; in composition they are mainly medium to light grey, crypto- to fine-grained, in part finely laminated and mainly thick bedded, and weather grey and buff. Map-unit 9, accordingly, totals 910 feet in thickness. The upper contact throughout Nahanni Range appears gradational but mappable. Similarly weathering beds which occur sporadically above the Camsell thrust of Camsell Range are provisionally included in this map-unit; they were not examined.

Sombre Formation (10)

Massive-bedded, grey-weathering dolomites that overlie, possibly unconformably, the Camsell formation, or map-unit 6 where the Camsell is not recognized, are designated the Sombre formation. The Sombre is overlain, apparently unconformably, by the Arnica formation. The Sombre formation is typically developed at the section on Delorme Range where it is 1,600 feet thick, and also on Tundra Ridge of Nahanni Plateau—described in Virginia Falls map-area (Douglas and Norris, D.K., 1960)—where 4,100 feet was measured. At the latter locality the formation is termed 'map-unit 14' and the three divisions—map-units 11, 12 and 13—are 1,160, 570, and 2,370 feet thick respectively. The Tundra Ridge section is the thickest measured and may be considered as the type section.

On Delorme Range the Sombre formation contains fine-grained dolomites—laminated, thinly and evenly bedded, and light brownish grey—grading to silty, fine-grained, granular, medium-grey, thin- to medium-bedded dolomites. These weather alternatingly grey and light grey. Some limestone—dolomitic, silty, dark grey, and thickly bedded; and dolomite—cryptograined and dark brownish grey—are present.

The formation is extensively developed throughout western and southwestern Root River map-area. The dark-weathering band forming the middle part of the formation is intermittently developed and has been shown separately. It is useful locally in establishing the formation, its sequence, and the structure, also in establishing the stratigraphic relationships to overlying Arnica formation. It may not constitute a reliable horizon and be equivalent everywhere shown.

As a result of pre-Arnica erosion the Sombre formation is thin in the eastern ranges of Mackenzie Mountains and is probably absent beneath most of Mackenzie Plain and Franklin Mountains.

Middle Devonian and Older (?)
(Map-units 11 to 17)

Arnica Formation (11)

The name Arnica is applied to a thick sequence of distinctively banded dark grey dolomites that generally overlies the Sombre formation. The formation is described as 'map-unit 16' in Virginia Falls map-area (Douglas and Norris, D.K., 1960) and the section at First Canyon on South Nahanni River is designated as the type section. The name is taken from Arnica Range in that map-area. As a stratigraphic unit the Arnica formation comprises part of the Lone Mountain formation of Kindle and Bosworth (1921), whose type

section is within Camsell Bend map-area at Lone Mountain. That formation spans a greater interval as the overlying beds (here called the Manetoe formation) and the underlying Silurian strata are apparently included. The formation may be overlain, interbedded with, or grade laterally into the Funeral and Bear Rock formations, and may be overlain by and partly laterally equivalent to the Landry and Manetoe formations (see Fig. 2). As the Arnica formation grades laterally into the fossiliferous Funeral formation of Middle Devonian age, it is of that age and possibly older.

Several sections of the formation were measured: on Pastel Creek on Delorme Range it is 2,100 feet thick; on Iverson Range at Root River gap it is 1,700 feet thick; and on Camsell Range a few miles north of the map-areas it is 1,340 feet thick. In general it consists of dark grey and black dolomite—fine- to cryptograined, granular to finely porous and vuggy, variably fetid, and in some places laminated. The rocks are generally massive but medium and dark grey colour-alternations give the rocks a distinctive bedded and banded appearance.

In south-central Root River map-area the Arnica formation is overlain by the Funeral formation, and there it is thinner than the sections previously described (compare in Fig. 1). It was examined on the east side of Whittaker Range where it is 700 feet thick and consists of alternating beds of dark- and medium-grey dolomite that is fine- to coarse-grained and partly brecciated. Some beds are crinoidal or coralliferous; others contain black chert bands, layers, or nodules. The formation thickens northward and westward as the overlying Funeral formation thins, but to the south, in northern Nahanni Plateau and Manetoe Range, it is much thinner and may be locally absent.

Manetoe Formation (12)

Throughout Camsell Range and northern Ram Plateau and Nahanni Range, the Arnica formation is overlain by a thin unit of massive, coarsely crystalline dolomite—here named the Manetoe formation. This formation is also well developed in Virginia Falls and Sibbeston Lake map-areas (Douglas and Norris, D.K., 1960) where it is described and designated as 'map-unit 18'. The occurrence in First Canyon on South Nahanni River where it overlies the Arnica formation may be considered to be the type section. The name is taken from Manetoe Range in Virginia Falls map-area.

The Manetoe formation on Camsell Range consists of about 150 feet of dark grey, coarse-grained dolomite—medium- to thick-bedded, highly fractured and cut by white calcite and dolomite veins. It was not examined on northern Ram Plateau, nor in south-western Root River map-area.

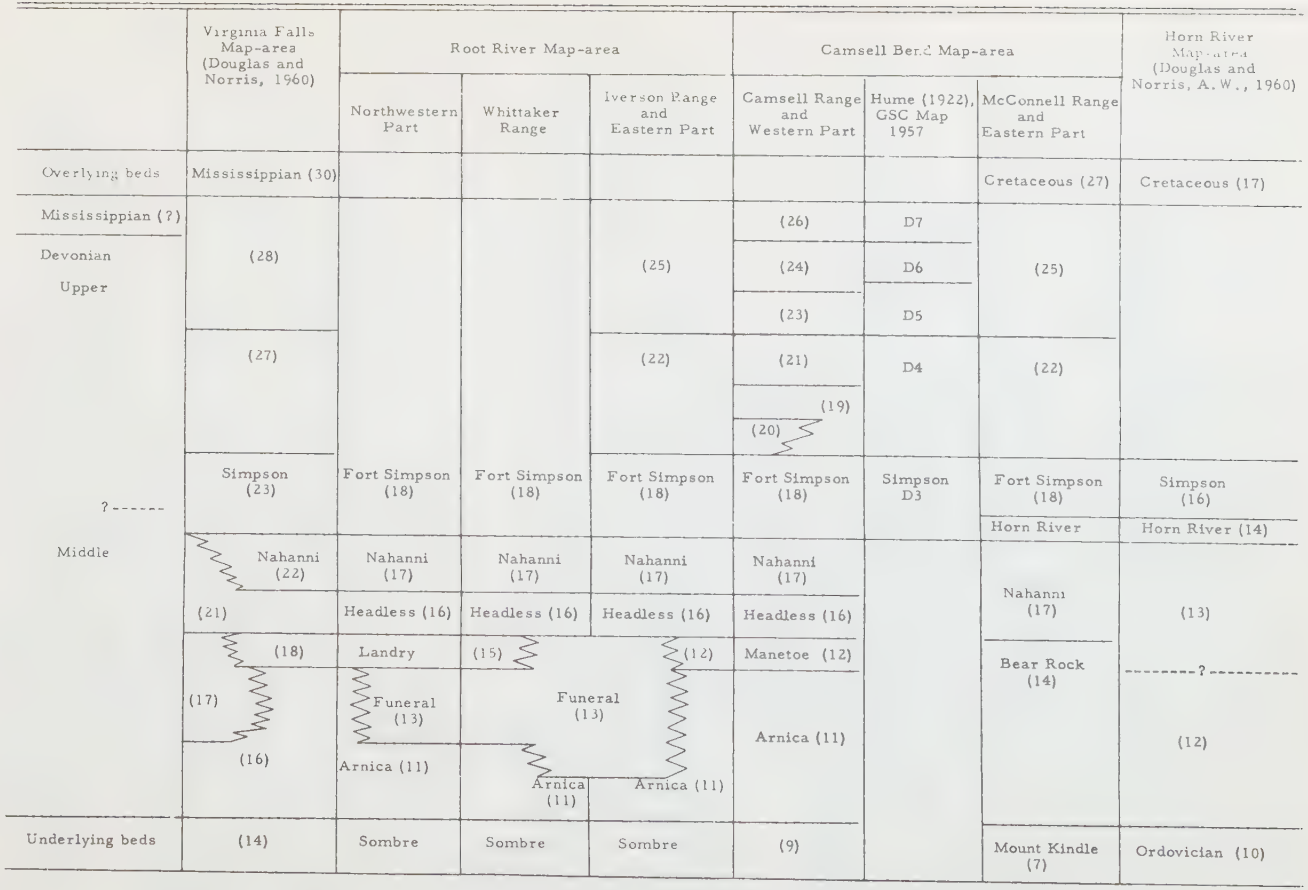

Figure 2. Correlation of Devonian formations and map-units of Camsell Bend, Root River and adjacent map-areas.

The stratigraphic relationships to the Funeral formation are clearly displayed on southern Iverson Range (see Fig. 2). On the east flank of Iverson anticline where the Manetoe forms a rugged cliff, it comprises an estimated 500 feet of medium-grey, coarse-grained, massive dolomite—very porous to cavernous, with the vugs lined with milky-white quartz crystals; the porosity is very high, a feature which may be associated with the margin of the facies change. To the north and south, and west across the anticline, the formation grades laterally into the upper part of the Funeral formation. On a tributary to Dekale Creek from the east, coarse, massive, medium-grey vuggy dolomite of the Manetoe formation underlies the upper part of the Funeral formation. At this locality the coarse dolomites of the Manetoe formation may occupy a considerable stratigraphic interval and separate the Funeral and Arnica formations. This relationship was also noted on southern Painted Mountains near North Nahanni River.

Funeral Formation (13)

In parts of Root River and Virginia Falls map-areas the dolomites of the Arnica and Manetoe formations grade laterally into buff, recessive-weathering limestones and shale, for which the name Funeral formation is proposed. The stratigraphic limits of the Funeral formation vary considerably as noted in the foregoing descriptions of the other formations, but the gradation from one facies to the next appears to be fairly rapid and abrupt. The section of 'map-unit 17' on Nahanni Plateau—described in Virginia Falls and Sibbeston Lake map-areas (Douglas and Norris, 1960)—is considered to be the type section.

The Funeral formation was examined on southern Iverson Range. Stratigraphic relationships to the Manetoe formation there have been previously described (see Fig. 2). The formation consists of about 900 feet of limestone—dark grey, fine-grained, mainly platy to thinly bedded, but also partly silty, argillaceous and finely laminated, and breaking down to a buff-weathering platy talus. Some medium-bedded, medium- to coarse-grained fossiliferous limestones occur near the top. Northeastward the Funeral formation grades into the Manetoe formation. To the north along the range, the lower part grades into the Arnica formation and the upper part into the Landry formation.

On the east flank of Whittaker Range and in parts of Delorme Range the Funeral formation occupies the stratigraphic interval between a thin part of the Arnica formation below and the Landry formation above (see Fig. 2). On Whittaker Range the basal 230 feet of the formation consists of interbedded limestones and calcareous shales—fine-grained, thinly bedded to platy, and medium grey; with thin beds of black chert. These beds are succeeded by 1,070 feet of interbedded limestones and shales. The limestones are thinly bedded, dark grey, fine grained, and weather light brown to dark grey and in places pink; they are interbedded with shales and calcareous shales—dark grey to black, and thinly bedded. The shale is proportionally

greater in the lower part of the formation. The limestones are variably fossiliferous and contain a Middle Devonian fauna according to McLaren. The Funeral formation is generally recessive and occupies talus-covered slopes; the fragments weather light buff to creamy and, locally along the eastern flank of Whittaker Range, distinctively pinkish. Northwestward, the lower part of the Funeral formation grades into the Arnica formation and the upper part into the Landry formation.

Bear Rock Formation (14)

Massive breccias occurring on McConnell Range of Franklin Mountains east of Mackenzie River are referred to the Bear Rock formation, in accordance with the usage of Williams (1923) and the Canol geologists (Hume, 1954). These breccias are composed of fine-grained, slightly silty and argillaceous, pale brown to dark grey limestones. They weather yellowish orange, in places soft and recessive and in other places more massive and cliff-forming. The formation was not measured within the map-areas but it is 1,100 feet thick in Wrigley map-area to the north.

Landry Formation (15)

The term Landry formation is here proposed for the grey-weathering, thick- to massive-bedded limestones that overlie the dolomites of the Arnica formation in northwestern Root River map-area and overlie or grade laterally into the recessive limestones of the Funeral formation in more southerly parts of the area. The section on Delorme Range may be taken as typical of the former development, and that on Whittaker Range as typical of the latter. The formation is everywhere overlain by the Headless formation (see Fig. 2).

On Whittaker Range the Landry formation is 400 feet thick. There it comprises medium-grey to black, crypto- to medium-grained limestone, in part pelletoid and fossiliferous or fossil-fragmental, medium- to thick-bedded and weathering light grey. The unit is very resistant to erosion relative to adjacent formations. Standing vertically, it forms a striking, irregular cockscomb ridge along the east flank of Whittaker Range. Individual beds towards the base may be seen to decrease in thickness and pass downward into the recessive, poorly exposed Funeral formation below. This facies change takes place from north to south along the range so that at the south end the Landry has graded into the Funeral. The limits of the formation relative to the Funeral as mapped, are based mainly on inferences drawn on relative resistance to erosion; the more-resistant, cliff- and ridge-forming parts are included in the Landry formation and the less-resistant, slope-forming, talus-covered beds are included in the Funeral formation.

On Delorme Range the Landry formation is represented by 300 feet of cryptograined, dark grey to black limestone—mainly thickly and evenly bedded, grey-weathering, partly silty and argillaceous towards the top and partly replaced towards the base by coarsely crystalline white to brown dolomite. The formation was also examined on northern Whittaker Range on the Root River gap where 500 feet was measured. This comprises medium-grey, fine- to cryptograined limestone—regularly medium- to thick-bedded, and partly dolomitized towards the base to fine- and coarse-grained, grey dolomite.

In northwestern Root River and southwestern Dahadinni map-area to the north, the formation is relatively resistant, forming the peaks and dip slopes of many mountains. There it was barren of fossils and was light grey weathering in contrast to the dark-weathering dolomites of the underlying Arnica formation. It is separated from the similar-appearing Nahanni formation by the persistently recessive Headless formation.

Headless Formation (16)

A persistent shale and argillaceous limestone unit that separates the Nahanni from underlying formations (see Fig. 2) is named the Headless formation. It is the facies equivalent of the Nahanni formation where the Nahanni is thin or absent. The sections and stratigraphic relations evident in Virginia Falls map-area (Douglas and Norris, D. K., 1960) in the vicinity of Headless Range, on a tributary to Meilleur Creek, and at First Canyon on South Nahanni River, are considered to be typical of the development of the Headless formation (designated 'map-unit 21' of that area). These facies variations are independent of the complex facies variations evident in the underlying beds and suggest that the base of the Headless formation is a disconformity.

In Camsell Bend and Root River map-areas the Headless formation consists of about 200 feet of dark grey limestone—argillaceous, thin-bedded, grey, and crypto- to fine-grained; interbedded with calcareous shale. It is abundantly fossiliferous, and is Middle Devonian in age according to McLaren and A. W. Norris. The formation forms a recessive interval between the underlying beds of the Manetoe and Landry formations and the commonly more massive limestones of the overlying Nahanni formation. Where underlain by the Funeral formation, as on Nahanni Plateau, the base of the Headless formation is drawn at the top of the relatively more resistant and light-buff-weathering limestones.

The formation was not examined on Camsell and McConnell Ranges. On the former range however, it is well represented physiographically by a strong recessive interval occupied by the formation in map-areas to the south and north, where it is 145 and 130 feet thick respectively. On McConnell Range the formation, if present, is included with the Nahanni formation (see Fig. 2).

Nahanni Formation (17)

Usage of the term Nahanni formation corresponds to that in the report on the adjoining Virginia Falls and Sibbeston Lake map-areas (Douglas and Norris, D.K., 1960). It involves a minor restriction of the original definition by Hage (1945), inasmuch as 'map-unit 21'—now termed the Headless formation—was recognized at the base.

In Root River map-area, the Nahanni formation consists of dark grey, fine-grained limestones, varying to medium-grained, fossil-fragmental and reefy. The limestones occur in medium to massive beds separated by thin argillaceous limestones or by argillaceous limestones of about equal thickness. The latter are more common towards the base, which is gradational into the underlying Headless formation. In general, the formation is less massive and less resistant than in the map-areas to the south.

The Nahanni is 830 feet thick on Delorme Range; 800 feet thick on Whittaker Range; and 600 feet thick on Root River in northern Iverson Range and 965 feet thick on southern Iverson Range. The formation thins eastward to Camsell Range where, just north of the map-area, it is 360 feet thick. There it consists of light to dark grey, medium- to coarse-grained limestone. The limestones are thick and medium bedded and occur in massive units separated by covered intervals that comprise about almost half of the formation. On McConnell Range the formation is about 300 feet thick; the basal part is mainly covered and may possibly be equivalent to the Headless formation. Fauna from the Nahanni formation is, according to McLaren, Middle Devonian in age.

Upper Devonian
(Map-units 18 to 25)

Fort Simpson Formation (18)

In Great Slave and Trout River map-areas (Douglas, 1959b) the term 'Simpson'—originally proposed by Cameron (1918)—was used for the shales occupying the stratigraphic interval between the Middle Devonian limestones and the overlying siltstones and shales of the 'D4 unit' of Hume (1922). The lower part of the latter beds, in Camsell Bend and Root River areas, is referred to as map-unit 19, 20 or 22 (see Fig. 2), and is approximately equivalent to 'map-unit 20' of Trout River map-area. Since the name 'Simpson' is pre-empted as a stratigraphic term, it is here proposed that the formation be known as the Fort Simpson formation after the full name of the settlement.

The formation as mapped may include beds at the base, that in the subsurface of Trout River map-area (Douglas, 1959b), are referred to the Spence River formation of Hunt (1954), and that in the adjoining Horn River map-area (Douglas and Norris, A.W., 1960) are referred to the Horn River formation of Whittaker (1922). The latter beds—the Horn River formation—include thin limestone beds with fossils of Middle Devonian age, and are the shale facies equivalent of some carbonate formations.

The Fort Simpson formation, where measured on Deceiver Creek on the west flank of Camsell Range, is 3,800 feet thick. It is thought to be faulted and the true thickness is probably about 2,500 feet. The basal beds are not exposed. The lower part of the formation consists of shale—non-calcareous, dark grey, fissile, and partly iron-stained; with some nodular beds of concretionary limestone and some thin interbeds of fine-grained siltstone. The upper part of the formation consists of mudstone—calcareous and silty, and medium to dark grey—interbedded with fine-grained, dark grey, argillaceous limestone and thinly bedded, laminated, fine-grained, calcareous siltstone and sandstone.

The Fort Simpson formation was encountered in the British American Hudson's Bay Lone Mountain Nos. 1 and 2 wells and the Trail Creek No. 1 well (see Appendix). In the latter two wells the basal beds consist of black shale that is partly silty and bituminous, and is thought to represent the Horn River formation of Horn River map-area to the northeast (Douglas and Norris, A.W., 1960). In the Lone Mountain No. 1 well, which reached a total depth of 2,905 feet, the Horn River beds were apparently not encountered. As the well started within the upper part of the Fort Simpson formation, the thickness of the formation may accordingly be somewhat in excess of 2,900 feet, assuming no tectonic thickening.

Map-unit 19

Map-unit 19 is well exposed on Deceiver Creek, on the west flank of Yohin syncline south of Carlson Lake and about 5 miles northwest of the lake. It is about 650 feet thick and comprises interbedded shale—olive-grey and silty; sandstone—variably calcareous; and siltstone—argillaceous, fine- to medium-grained, and grey to greenish grey.

Map-unit 20

Within the basal beds of map-unit 19 or where equivalent beds are included in map-unit 22, limestone reefs are locally present and are mapped separately as map-unit 20. Southeast of Carlson Lake the map-unit consists largely of stromatoporoids and corals forming a massive, poorly bedded limestone. Some beds are medium-grey,

coarse-grained, pelletoid and fossil-fragmental. North of Root River, argillaceous and silty limestones with abundant fossils are overlain by coralliferous, massive limestones and fragmental and pelletoid limestone—light grey to brownish grey and devoid of bedding. The reef limestones there are about 150 feet thick. The gradation westward into the clastics of map-unit 19 is well displayed on the tributary from the west to Carlson Creek which enters 18 miles above the mouth. The occurrence east of Camsell Range was not examined.

Map-unit 21

Map-unit 21 consists of about 660 feet of sandstone—calcareous, grey to greenish grey, and thickly bedded; interbedded with mudstone—silty, calcareous, olive-grey, and thinly bedded; siltstone—fine-grained, argillaceous, and greenish grey; and limestone—argillaceous, medium-grey, and fine- to cryptograined. The latter occurs mainly at the top.

Map-unit 22

East of Camsell Range in Camsell Bend map-area, and throughout Root River map-area where map-units 19-21 are indivisible, the combined equivalents are represented as map-unit 22.

On lower Root River, resistant limestones at the top of the unit form a small cliff and constitute a locally mappable division. These beds are light grey, fine-grained, silty and sandy limestone—thin- to medium-bedded and interbedded with calcareous shale. Elsewhere within the map-areas these resistant limestones do not appear to be well represented and are not readily separable. Fossils collected from the limestones east of Camsell and Nahanni Ranges are Famennian in age according to Sartenaer. Underlying beds are greenish grey calcareous shale with some thin beds of silty limestone; no fossils were found in these beds.

Map-unit 22 was not examined in Root River map-area. The distribution shown is that of the relatively resistant beds that form ridges and cap many of the low hills, and generally separate the dark shales of the underlying Fort Simpson formation from the creamy-weathering and varicoloured shales of overlying map-unit 25.

Map-units 23 to 25

Map-units 23 and 24 were examined only in the axis of the Yohin syncline south of Carlson Lake in Camsell Bend map-area. There unit 23 consists of about 700 feet of shale—slightly calcareous and silty, and grey to greenish grey; with thin limestone bands—fine-grained and silty; and siltstone—calcareous, green, and thinly bedded; these grade to fine sandstone. Map-unit 24 comprises about 575 feet

of siltstone—calcareous, argillaceous, and very thinly bedded; interbedded with shale—silty and calcareous, light green to reddish brown, and weathering a distinctive maroon to reddish brown. The upper 50 to 100 feet is mainly limestone—argillaceous, greyish brown, thinly bedded, fine- to medium-grained, and fossiliferous. These beds contain the youngest Upper Devonian fossils known in the area, and are of late Famennian age according to Sartenaer.

Map-unit 25 represents the undivided equivalents of map-units 23 and 24. These beds, mainly shale, are recessive and are poorly exposed throughout most of the map-areas. They weather a creamy-buff to light tan; they are commonly talus-covered but are dark in colour where freshly exposed. Seen locally within those areas indicated as underlain by map-unit 25, are the reddish weathering beds presumably equivalent to the lower part of map-unit 24. Insufficient ground control did not permit separate mapping of these units throughout the area. Map-unit 25 may also include younger beds that are possibly equivalent to map-unit 26 or to the Cretaceous map-unit 27. Where examined the basal beds consist of mudstone—calcareous and silty, and greenish grey; with harder, more calcareous bands of argillaceous limestone—silty, light grey to olive-grey, and abundantly fossiliferous. Also seen were pale yellowish orange limestone and shale—fissile, non-calcareous, green, red, and purple with greenish grey mottling; and thinly bedded sandstone—weakly calcareous, greyish red-purple, and very fine-grained.

Mississippian (?)

Map-unit 26

The youngest beds exposed in the trough of Yohin syncline southeast of Carlson Lake are included in map-unit 26; this unit corresponds to 'unit D7' of Hume (1922). About 100 feet is present, of which the basal 50 feet is covered. The exposed beds are shale—steely-grey with tinges of green and mauve, very fine and compact, and weathering fissile and into small chips. Rare, very thin, iron-stained sandstone beds are also present. Map-unit 26 overlies beds containing the youngest Upper Devonian fossils known in the general region and accordingly the unit may be post-Devonian in age. It could be part of a thick succession of Mississippian shales present in Sibbeston Lake map-area to the south (Douglas and Norris, D.K., 1960) or pre-Fort St. John group of the Cretaceous. No fossils were found.

MESOZOIC

Cretaceous

Map-unit 27

Much of Camsell Bend map-area is shown underlain by strata of Cretaceous age. The distribution is inferred mainly from data available in adjacent regions. No outcrops were examined within the map-area. The outcrops shown on Ebbutt Hills, south of Willowlake River, were examined by Dann (1952) who described the beds as consisting of shale—dark grey to black, partly bituminous, very fissile, weathering grey with yellow stains, and containing numerous ironstone bands and concretions, minute selenite crystals and cone-in-cone structures. These rocks are lithologically similar to 'map-unit 20' of Horn River map-area (Douglas and Norris, A. W., 1960) or 'map-unit 16' of the Fort St. John group of Fort Liard map-area (Douglas and Norris, 1959).

STRUCTURAL GEOLOGY

The structural elements in the successive physiographic subdivisions in Camsell Bend and Root River map-areas will be dealt with mainly from east to west, except where certain elements are more naturally treated along rather than across strike.

The principal structural element in southern Mackenzie and Franklin Mountains is the fold. Its axial surface may dip on either side of the vertical, with a corresponding change in symmetry. Where folds have been observed—and this was predominantly in the more competent rocks of the Middle Devonian and older—they appear to approximate parallel folds with rounded flanks. They are commonly thrust faulted on their flanks and the stratigraphic succession is thickened or thinned, depending on the attitude of the fault surface with respect to the bedding.

Many of the folds are linked en échelon and hence trend obliquely to the principal structures so that the major fold elements of which they are a part are commonly disguised. Both zig-zag and elliptical linkages are evident, although the former are prevalent.

Many thrust faults are secondary structural elements, particularly where they are closely associated with the folds. The fault surface may dip either east or west; commonly the relative displacement of hanging-wall beds is in the direction of asymmetry of the fold. Relative movement has been largely up the dip but many faults appear to have significant strike-slip components.

Within that segment of the western Interior Plains with which this report is concerned, little is known of the bedrock geology because of the widespread mantle of glacial debris. The assumed distribution of Cretaceous rocks however, would suggest that these and underlying Upper Devonian strata are essentially flat-lying. This assumption is confirmed by sparse outcrops of Fort Simpson shales along Willow Lake River. Toward the western margin of the Interior Plains these shales are locally undulating, and dips of up to 35° were reported along Willow Lake River south of Willow Ridge.

Along Willow Ridge, Middle Devonian rocks form a doubly-plunging fold, here termed Willow Ridge anticline. Its flanks dip from 30 to 75°. The north plunge is gentle and the fold apparently dies out a short distance beyond the north boundary of the map-areas. The fold plunges more steeply to the south and was not recognized as a major structure on Willow Lake River. There Fort Simpson shales are gently undulatory and also dip north on the approximate structural continuation of the fold.

The southernmost element of McConnell Range is an anticlinal fold in Middle Devonian rocks that lies left-hand en échelon with respect to Willow Ridge anticline. This element is strongly asymmetric eastward with strata on its west flank dipping 25 to 35° and with its east flank commonly nearly vertical. It appears to be faulted along its east flank and it plunges southward near the mouth of Willow Lake River. At Old Fort Island in Mackenzie River, the southern extremity of the main structural element of McConnell Range is formed of gently-west-dipping middle Devonian rocks underlain by a northwest-dipping thrust fault.

Between McConnell Range and Camsell Range, upper Devonian rocks are folded into the Root River syncline and anticline. Minor folds occur on the west flank of the anticline. The folds appear to be limited by a fault which is inferred to extend from the Camsell thrust to join the fault beneath the middle Devonian rocks on Old Fort Island. East-west closures on Root River anticline are estimated to be 2,500 and 5,000 feet on the top of the middle Devonian in cross-sections AB and CD respectively of Root River map-area. The structure plunges gently northward, whereas southward the existence of closure is conjectural.

Camsell Range lies right-hand en échelon with respect to McConnell Range and left-hand en échelon with respect to Nahanni Range. It is structurally analogous to Nahanni Range in that it consists of a west-dipping, essentially homoclinal succession in Middle Devonian and older rocks, with some Upper Devonian shales involved in the complex folds and faults of the structurally low areas. Throughout its length Camsell Range is underlain by Camsell thrust, which at the surface appears to dip gently west but in places may be nearly flat.

The homoclinal segments of Camsell Range are generally north trending although sinuous in detail; the various segments are aligned north, northwest and northeast. Just south of Root River, hanging-wall strata of Camsell thrust are folded into a number of anticlines and synclines that are linked left- and right-hand en échelon and exhibit closures of from 1,000 to 2,000 feet on the top of the Nahanni formation.

Except for the area immediately south of Root River, Camsell thrust maintains a moderately constant stratigraphic position along strike with respect to hanging-wall beds, and appears to parallel the bedding or to cut across it at rather shallow angles. It extends beyond the north boundary of the map-area and appears to merge southwards with Nahanni thrust near the mouth of North Nahanni River.

Yohin syncline in Camsell Bend map-area is the northern continuation of a major structural element from adjacent Sibbeston Lake map-area. It lies west of Camsell Range and reaches its maximum structural depression near Deceiver Creek—a tributary of North Nahanni River. Throughout its length it is a broad, open fold with the flanks dipping symmetrically less than 40°.

Ram anticline—a north-trending, doubly-plunging flexure—lies right-hand en échelon with respect to the southern termination of Camsell Range and is flanked on the east by North Nahanni River. The anticlinal folds at the north and south ends of the structure are linked right-hand en échelon. Stripped surfaces on the resistant limestones of the Nahanni formation indicate the general form of the structure. Dips are gently westward on the west flank and from 40° eastward to near vertical on the east flank where the structure is apparently broken by a west-dipping thrust fault. North of Carlson Lake, Ram anticline is evident in upper Devonian rocks and plunges northwest in eastern Root River map-area. The culmination within Middle Devonian rocks beneath this part of the anticline may however lie en échelon to that exposed in Ram Plateau.

English Chief syncline extends from a few miles south of North Nahanni River to beyond the north boundary of Root River map-area. It appears to consist of two synclines linked left-hand en échelon in the vicinity of English Chief River. Upper Devonian strata generally dip from 5 to 15° on its flanks; locally dips may increase to 30-40°, as in the vicinity of Root River. The axial region of the syncline generally contains Upper Devonian strata. Toward the south end of the structure however, strata of possible Mississippian age are present.

English Chief anticline is a compound fold structure that lies west of English Chief syncline and is bounded on the west by Tundra thrust. It is composed of several small anticlinal elements linked left-hand en échelon. Middle Devonian rocks are exposed in the southern element and appear in Dahadinni Range north of the map-area.

Mackenzie Mountains within Root River map-area may be divided into three areas of somewhat different structural habit and termed the 'eastern', 'central' and 'western' areas. The eastern area includes the Iverson and Whittaker Ranges and the western area the Painted and Sombre Mountains and Thundercloud Range. These areas are characterized by rather open folds and by east- and west-dipping faults with mainly dip-slip components. The central area on the other hand is a northwest-trending belt about 5 miles wide, in which the structure is considerably more complex. The tighter folds are broken by several faults. This area is the structural continuation of the region between Tundra and Manetoe thrusts of Virginia Falls map-area (Douglas and Norris, D.K., 1960), and it coincides with the boundary between the Canyon and Backbone Ranges as described here under Physical Features.

Iverson Range is the eastermost range of the Mackenzie Mountains in Root River map-area and correspondingly lies within the eastern area mentioned above. Throughout its length it is underlain by Iverson thrust—a major west-dipping fault with shallow to moderate dips along its surface trace. In the northern part the hanging-wall succession is essentially homoclinal, dipping west about 30° with minor folds trending diagonal to the range and linked to form an elliptical pattern. On the other hand, in the southern part and in northern Nahanni Plateau, the succession is folded along axes that parallel the strike of the thrust and extend for many miles.

Trench Lake syncline lies immediately west of Iverson Range. In its central part it is acute, but it is broader at the ends. It trends approximately north and exhibits little plunge in the south where it ends on the north flank of Nahanni Plateau. Strata of the Fort Simpson formation form the core of the structure for most of its length.

Whittaker anticline—the dominant positive element west of Trench Lake syncline—is a major dome-shaped feature which culminates at the headwaters of English Chief River. It is moderately asymmetric eastward near the culmination, with dips nearly vertical along its east flank and from 35 to 70° along its west flank. Whittaker anticline exposes the oldest strata (map-unit 1) of the area. It plunges northward into Delorme syncline and southward into Trench Lake syncline. With respect to the base of the Camsell formation, Whittaker anticline has both east-west and north-south closures of about 5,000 feet. Northern Whittaker Range is essentially an anticline, generally asymmetric eastward, and modified by minor thrust faults, most of which have their west sides displaced relatively upwards.

Delorme syncline extends from the vicinity of North Nahanni River beyond the north boundary of the map-areas. Like many of the major synclines of Liard Range and northeastern Liard Plateau, it exhibits a strongly sinuous course with reversals in plunge intimately

associated with changes in direction of the trace of the axial surface. In general, where the axis rises, it has a northwest trend, and where it falls it has a northerly trend. It is asymmetric eastward except in the vicinity of Root River where the dip of the axial surface reverses and the fold assumes a strong westward asymmetry.

In southern Delorme Range, between the Delorme syncline and fault, is a series of south-plunging folds, some broken by east- and west-dipping faults. In the vicinity of North Nahanni River the folds are more acute and closely spaced and terminate near or are offset by a northeast-trending fault on which transcurrent movement appears to have taken place.

The principal elements in the narrow central area are Manetoe anticline, Landry syncline, Spirit fault and the Delorme Range structure. Manetoe anticline extends from North Nahanni River to the south boundary of the map-area. It is asymmetric westward near its culmination and it is modified by thrust faults, especially along its west flank and its axial region. There east-dipping thrust faults cut west-facing panels and the stratigraphic succession is thinned. On the southeastern flank are the northern terminations of the Tundra thrust fault and a subsidiary east-dipping thrust fault of Virginia Falls map-area. Both end abruptly on northeast-trending faults on which transcurrent movement appears to have taken place.

Landry syncline lies right-hand en échelon to Manetoe anticline and extends from North Nahanni River to within a few miles of Root River. Throughout its length its axial surface deviates little from a north-northeast trend in contrast to that of folds in the areas to the east and west. Locally its flanks are modified by thrust faults and folds, as on the west flank near the headwaters of Landry Creek.

Spirit fault trends north-northeast across Landry syncline and appears to truncate or offset all structures in the vicinity. It is locally the western limit of the central complex belt. Offset relations suggest transcurrent movement along it. The continuation of Landry syncline north of Spirit fault is decidedly asymmetric; its axial surface dips east and its east flank is cut by a minor east-dipping thrust, which results in a thinning of the succession.

Along the north boundary of the map-areas the western limit of the central area is considered as the east-dipping thrust that repeats part of the succession on the west flank of Landry syncline north of Spirit fault. It is a major thrust in adjacent Dahadinni River map-area.

Delorme Range is essentially an anticline—moderately asymmetric eastward, and modified by major east- and west-dipping thrust faults in its axial region. There, east-dipping Delorme fault

cuts west-dipping strata and the succession is thinned. Northward Delorme thrust gives way to two west-dipping thrusts in the core of the anticline, and in the vicinity of Root River they appear to offset one another (see cross-section AB, Root River map-area).

The principal structural elements of the western area are Amber and Painted Mountain anticlines, Wrigley and Thundercloud synclines, and Painted Mountain, Bell Heather and Clearwater faults. The folds are, in general, open structures modified by thrust faults that may dip either east or west.

Amber anticline in the northwest corner of Root River map-area is asymmetric westward and doubly plunging. Its axial surface dips steeply eastward and the fold culminates in the vicinity of Root River. This anticline plunges gently northward and ends a short distance north of the map-areas and plunges steeply southward where it is cut and apparently offset by Spirit fault and an associated splay. The counterpart of Amber anticline is a strongly asymmetric syncline immediately to the west. Its east flank is near vertical whereas strata on its west flank dip from 5 to 10°. The syncline plunges southward and its continuation south of Spirit fault is cut by a minor west-dipping thrust.

South of Spirit fault is Painted Mountain anticline—asymmetric westward in Sombre Mountains south of North Nahanni River and underlain by Painted Mountain thrust. Northward in southern Painted Mountains it is more symmetrical, with gently dipping beds forming a broad crestal region bounded by anticlinal bends with vertical beds on their outer flanks.

Painted Mountain thrust trends north-northwest and extends from northern Virginia Falls map-area for an unknown distance beyond the west boundary of Root River map-area. Its hanging-wall lies on its east side. Merging with it about the latitude of North Nahanni River is a folded thrust on which the east side has moved relatively upwards. A minor klippe and fenster occur about midway along the structure.

The northern continuation of Wrigley syncline from Virginia Falls map-area is, in general, a flat-bottomed structure with a west-dipping axial surface. For most of its length it has a gentle northward plunge, but at its northern extremity the plunge is reversed so that it is structurally lowest a few miles north of where it is crossed by North Nahanni River.

What may be a anticline west of the area rises abruptly from the west flank of Wrigley syncline. It plunges steeply to the southeast so that there is little expression of it at the structural level of the Nahanni formation on the flank of Wrigley syncline.

Bell Heather thrust is a major feature in the southwest corner of the area. It extends an unknown distance beyond the map-areas to the northwest and dies out on the south flank of Sombre Mountains in adjacent Virginia Falls map-area. Between Bell Heather thrust and Wrigley syncline, Ordovician and Silurian rocks are folded into a series of open structures. The most easterly of these is termed Thundercloud syncline, flanked on the east by a major west-dipping thrust fault which begins about the latitude of Bell Heather Lake and extends an unknown distance beyond the map-areas to the northwest.

Clearwater fault in the extreme southwest corner of Root River map-area trends northwest and dips northeast. Like Bell Heather thrust it extends beyond the area to the northwest and dies out on the north flank of Sombre Mountains in adjacent Virginia Falls map-area. Between Clearwater and Bell Heather faults is Sombre syncline—a very broad, flat-bottomed structure with strata on its west flank dipping about 55° and those on its east flank, although locally folded, generally dipping 5 to 10°. It dies out near the south boundary of the map-areas and extends beyond the west boundary.

ECONOMIC GEOLOGY

Oil and Gas

Several wells have been drilled within the map-areas (see Appendix); none penetrated the Precambrian basement. British American Hudson's Bay Trail Creek No. 1 and Lone Mountain No. 2 wells lie within the Plains part of the map-areas. These wells are drilled into rocks thought to be equivalent to the formations designated as Middle Devonian in age in the Franklin and Mackenzie Mountains. The British American Hudson's Bay Lone Mountain No. 1 and Root River No. 1 wells are drilled into Upper Devonian strata.

Pre-Devonian (pre-Arnica and pre-Bear Rock formations of this report) are known in Mackenzie Mountains, from the Franklin Mountains mainly at Cap Mountain north of the area as described by Williams (1922, 1923), and from Horn River map-area to the east (Douglas and Norris, A.W., 1960). The succession beneath the Devonian cover of Mackenzie Plain and the western part of the Interior Plains may be inferred from a consideration of this data. In general, in the region between Mackenzie Mountains and McConnell Range, the part of the Mackenzie Mountain succession between the Arnica and the middle Whittaker formations is progressively bevelled, presumably mainly as a result of pre-Arnica erosion. These strata are not represented on McConnell Range where the Bear Rock formation lies on the Mount Kindle formation (see Figs. 1 and 2). Accordingly, porous strata of the Sombre and Delorme formations and of map-unit 6 may lie in structural situations favourable for the accumulation of oil and gas, both as stratigraphic- and structural-type traps.

The massive, coralliferous and fossiliferous dolomites of the middle Whittaker formation and its probable equivalents—the Mount Kindle formation and map-unit 8—are thought to be widespread. The succession in eastern Camsell Bend map-area may be expected to have many features in common with McConnell Range north of the map-area and at the margin of the sedimentary basin as noted in Horn River map-area. Potential reservoir rocks are the basal Palaeozoic sandstones that are Ordovician or older in Horn River map-area and Cambrian at Cap Mountain, and the dolomites of the Mount Kindle and Franklin Mountain formations and probable equivalent—'map-unit 10' of Horn River map-area. As the Devonian lies in contact with the Precambrian basement in parts of Trout River map-area (Douglas, 1959b) to the southeast, it is possible that these dolomites are absent in the southeastern part of Camsell Bend map-area.

Strata of Devonian age exhibit many features which indicate that they are favourable source rocks and potential reservoir rocks. The Middle Devonian rocks, in general, converge in thickness from west to east and vary greatly in lithology; these changes are commonly abrupt between porous and non-porous facies or potential reservoir and source rocks. The dolomites of the Arnica formation, which are partly finely porous, and the coarse, vuggy and very porous dolomites of the Manetoe formation, grade laterally on the one hand into shales and argillaceous limestones of the Funeral formation; and, on the other hand, into dense dolomites, breccias and evaporites of the Bear Rock formation. There are indications that these two lines of facies change are very irregular. The former facies change is of significance in assessing the potentialities of Mackenzie Plain west of Camsell Range, and the latter of the region east of the range.

Variations within the Landry and Nahanni formations occur between dense, evenly bedded, cryptocrystalline limestones and more massive limestones that are fossiliferous and biogenic in part. The Landry may grade laterally into the upper part of the Funeral formation and the Nahanni into the shales and argillaceous limestones of the Headless formation and also possibly into the black bituminous shales of the Horn River formation. In addition to the possible occurrence of these porous facies of the Middle Devonian beds in the structurally closed parts of the folds of Mackenzie Plains and the western Interior Plains, the changes from porous to non-porous facies may occur in structural positions which are such that stratigraphic traps are produced.

The Upper Devonian comprises dark shale of the Fort Simpson formation, overlain by porous sandstones and limestone reefs. Some of the sandstones of map-units 19 and 21 appear to be local in distribution and grade into shale. The reefs of map-unit 20 appear to occur as several separate bodies that are restricted in development to a narrow belt trending roughly northwest to southeast. Although the

Upper Devonian lies at the surface over much of the map-areas and constitutes the cover for the older formations, there may be certain regions where these porous rock types are sufficiently deeply buried beneath later Devonian and Cretaceous rocks that they may be considered potential reservoirs.

In the eastern part of Root River and the western part of Camsell Bend map-areas, the Upper Devonian rocks lie at the surface and exhibit many folds. The principal structures are the English Chief, the Ram and the Root River anticlines. In addition there are minor anticlinal folds and noses subsidiary to these structures and the associated synclines; minor fault slices; and several large folds in which Middle Devonian and older rocks are exposed. All these structures are thought to have some prospects for oil and gas; the principal anticlines, of course, rank highest. But even the minor structures and the flanks of structures may be important, particularly in association with the stratigraphic relationships outlined above.

English Chief anticline is the westernmost anticline within Mackenzie Plain. Middle Devonian rocks are exposed in a sharp culmination south of North Nahanni River and, north of the map-areas they appear in Dahadinni Range. There are some indications that the central parts lie en échelon with respect to those parts in which older beds are exposed, and, following the structural habit of the region, would be expected to constitute separate, closed anticlinal structures.

A similar relationship is thought to occur between the northern end of Ram anticline and the southern part of the fold where Middle Devonian rocks are exposed in Ram Plateau. The fold plunges rapidly northwestward and ends in the flank of English Chief syncline. A change of trend and a change in symmetry suggest that the northern part lies en échelon to the southern part and would be, accordingly, separated by a structural low. Furthermore, just south of Carlson Lake, the beds of map-unit 19, although dipping east, must lie very close to the crest; and as they lie at elevations considerably lower than on the crest of the fold north of the lake, a southern closure is suggested.

Root River anticline is a large fold which plunges northeastward, but, as already noted, southern closure is only conjectural owing to bedrock cover by alluvium. Several possible structural relationships may be considered. The Root River anticline may be the structural continuation of the northern end of Nahanni Range, where prospective producing horizons are exposed. Even if this is so, there is a possibility that the part of the fold northeast of Root River is separated left-hand en échelon from Nahanni Range. Alternatively it is possible also that Nahanni and Camsell thrusts join; Camsell thrust merging with Nahanni thrust south of Lone Mountain and Nahanni thrust crossing North Nahanni River to merge with Camsell thrust farther north. The two thrusts would accordingly constitute parts of the same

general structure and Root River anticline would lie in the foot-wall beds. As beds of map-unit 22 are present in the foot-wall of Nahanni thrust, a southern closure on Root River anticline and the presence of other en échelon folds may be inferred in the vicinity of Camsell Bend.

The northeast-trending fault shown extending from Camsell Range to Old Fort Island is largely conjectural. There are, however, indications of relative southeasterly-directed movements within the Upper Devonian rocks. There appear to be regions northwest of this fault where the Middle Devonian rocks may be inferred to lie relatively high.

East of Mackenzie River are the major anticlines of southern McConnell Range and Willow Ridge. The trend and relative structural position of these anticlines suggest that fold and fault structures, probably intermittent, may extend southward, east of Nahanni Range, to join with the Bovie Lake structures of Fort Liard map-area (Douglas and Norris, 1959). As there seems to be no definite eastern limit to the orogenic structures it is possible that folds of this type and more gentle ones lie beneath the western parts of the Interior Plains.

Copper

Azurite and malachite were found in the core of Whittaker Range. They appear to occur in small veins and at two stratigraphic horizons within the Sunblood formation, map-unit 1 (see Stratigraphy).

- APPENDIX -

LOG OF WELLS

British American Hudson's Bay Root River No. 1 Well

Location: lat. 62°25'N, long. 123°16'W

Elevation: 370± feet (K. B.) Total depth: 2,780 feet

Summary of log by D. C. Pugh of samples stored at the Geological Survey of Canada, Calgary, Alberta

Depth (feet)	
0-200	Drift
	Map-unit 24
200-600	Shale, calcareous and silty, greenish grey, greyish buff and maroon; and siltstone, calcareous, fine- to medium-grained, grey and greyish buff
600-820	Shale and siltstone, as above; with limestone, silty and argillaceous, cryptograined, pale buff, in part fossiliferous
820-1,100	Shale and siltstone as above; minor limestone
	Map-unit 23
1,100-1,990	Shale, calcareous to slightly calcareous, partly silty, grey, dark grey and greenish grey; with minor siltstone, calcareous, fine-grained, grey; and limestone as above
	Map-unit 22
1,990-2,070	Limestone, dark brown to buff, cryptograined, dense, in part fossiliferous
2,070-2,780	Siltstone, calcareous, fine- to medium-grained, grey to buff; and shale, calcareous and silty, grey to dark grey

British American Hudson's Bay Lone Mountain No. 2 Well

Location: lat. 62°08'N, long. 122°40'W

Elevation: 395± feet (K. B.) Total depth: 2,645 feet

Summary of log by H. R. Belyea of samples stored at the Geological Survey of Canada, Calgary, Alberta

Depth (feet)	
0-305	Silt and very fine sand
	Fort Simpson Formation
305-890	Shale, medium to dark grey, non-calcareous; silty below 510 feet
890-1,270	Siltstone, calcareous, light and dark grey, micaceous, quartzose; shale as above
	Horn River Formation
1,270-1,330	Shale, black, with brown streak, hard, siliceous, silty and very pyritic
1,330-1,380	Shale, dark grey to black, hard, silty, finely micaceous; varying to siltstone, dark brownish grey
	Nahanni Formation
1,380-1,640	Limestone, dark brownish grey, crypto- to fine-grained, in part stromatoporoidal, chalky and finely porous
1,640-1,780	Limestone, dark and light brown, fine-grained, partly argillaceous
	Headless Formation
1,780-1,880	Limestone, argillaceous, dark brownish grey, cryptograined; slightly dolomitic below 1,850 feet
	Landry Formation
1,880-2,010	Limestone, white, cryptograined, partly porous; minor green shale at top
	Arnica Formation
2,010-2,470	Dolomite, cryptocrystalline to finely crystalline, buff to dark brownish grey; in part finely porous and sugary-textured
2,470-2,645	Dolomite, cryptocrystalline, light grey to pale buff

British American Hudson's Bay Trail Creek No. 1 Well

Location: lat. 62°04'N, long. 122°12'W

Elevation: 405 feet (K. B.) Total depth 1,520 feet

Summary of log by H. R. Belyea of samples stored at the Geological Survey of Canada, Calgary, Alberta

Depth (feet)	
0-220	Samples missing
	Fort Simpson Formation
220-410	Shale, grey to greenish grey, slightly calcareous
410-540	Shale, as above, with siltstone laminae and carbonaceous streaks; pyritic at 500-540 feet
	Horn River Formation
540-640	Shale, black, with dark brown streak, in part silty, pyritic
	Nahanni Formation
640-950	Limestone, crypto- to fine-grained, dark brown to buff, with black shale laminae below 750 feet
950-990	Dolomite, finely crystalline, greyish buff
990-1,050	Limestone, greyish brown, cryptograined; some black calcareous shale
	Bear Rock Formation
1,050-1,210	Dolomite, finely crystalline, brown
1,210-1,440	Anhydrite, white and brownish grey; with dolomite buff, cryptocrystalline
1,440-1,520	Anhydrite, white, crystalline